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# Effect of Stand-Up Paddle Boarding on Hydration Status in Recreational and Competitive Individuals

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ABSTRACT

***International Journal of Exercise Science 14(6): 756-767, 2021.*** Stand up paddle (SUP) boarding is a popular water-based aquatic sport and recreational activity that continues to grow in popularity, however, little is known about its effect upon hydration status in recreational and elite level participants. The aim of this study was to examine the hydration status in SUP by investigating fluid loss through measurement of nude body mass. Thirty participants successfully completed the study. Hydration status was assessed by measurements of nude body mass taken pre and post SUP session. Intensity of the session was monitored throughout each session using a telemetry heart rate (HR) monitor; both mean and maximum HRs were assessed. Environmental conditions were recorded prior to each session and participants rated perceived hydration pre and post activity. SUP sessions average duration was 68 ± 13 mins (mean HR: 135 ± 20 bpm, peak HR: 167.1 ± 12 bpm). The average mass lost in a SUP session was 0.82 ± 0.4 kg (absolute), 0.03 ± 1 (relative BMI), 0.43 ± 0.2 (relative BSA) and the overall percentage of loss was 1.2 ± 0.6 % ($p < 0.01$, $d = 0.47$). Key predictors ($p < 0.05$) of fluid loss included ambient air temperature, gender (males), mean HR and SUP session duration. Results from this study suggest that SUP participants may require fluid loss monitoring to allow for effective rehydration strategies. Pre-hydration strategies are also recommended to avoid dehydration which is associated with decreased performance (aerobic and strength), increased core temperature, heart rate and may lead to detrimental health outcomes such as renal failure and heat illness in extreme circumstances.

KEY WORDS: Water sports, paddle sports, SUP, hydrate, fluid changes, dehydration

## INTRODUCTION

Stand up paddle (SUP) boarding has seen significant growth in popularity over the last decade both in recreational and elite sporting environments. The sport continues to experience expanded participation globally, with the United States alone increasing by 1.7 million participants between 2010 and 2014 (3). The activity of SUP requires the participant to stand and balance effectively on a large board and propel themselves forward using a large paddle (17, 18). To be able to move the board through the water, the participant is required to isometrically contract throughout their lower limbs, gluteals, and trunk while rhythmically alternating their strokes from side to side using the paddle**.** The pull force from each stroke requires the body to counter the rotational force of each paddle pull through (18).

Stand up paddle boarding, both as a sport and a recreational activity, involves intermittent bouts of physical effort of varying intensity and duration. There are now a wide variety of competitive SUP events that people compete in worldwide. These include SUP surfing, SUP technical racing, SUP distance racing, SUP sprint racing (including downwinder in open ocean and flat-water) and SUP paddle relay. In addition to shorter bouts, SUP distance racing ranges from 5 km to the longest race at 715 km held on the Yukon River (Yukon River Quest) in Canada. Generally, race distances are between 5 – 21 km (22). Although some of these distances may only be seen in elite groups, recreational level paddlers may also spend upwards of one hour or more paddling their boards if the environmental conditions are suitable (17). Given the alternating and often challenging physical demands of this sport, it may be presumed that SUP could lead to significant fluid loss via sweat, as with other forms of physical activity. Therefore, effective maintenance of hydration is vital for the performance, health, and well-being of the participant. Despite its increasing popularity, the physiological impacts of SUP are still under-researched and therefore poorly understood.

Fluid loss is a common occurrence during most bouts of physical activity and varies amongst individuals and environmental conditions. Fluid intake requirements are often low for sports that are intermittent, short duration (less than 1 hour), and of lower exercise intensity (8). Many modes of physical activity, like SUP, last well over an hour in duration, which results in hydration becoming a concern (8, 17). Furthermore, literature suggests that individuals participating in activities that primarily require aerobic metabolism for prolonged durations are more likely to experience dehydration than those that primarily require anaerobic metabolism, strength, and power (6). Due to the relationship between hydration , thermoregulation, and cardiovascular function, a lack of hydration while exercising could have both performance and health and safety implications (23). Physiologically, dehydration has been shown to be deleterious to exercise performance and overall safety of an athlete due to increased thermoregulatory and cardiovascular system stress, leading to conditions such as heat stress, heatstroke, heat exhaustion, and, in extreme cases, death.

The importance of hydration has been extensively investigated in both land-based and aquatic sports (6, 8, 11). While we can acknowledge the need for hydration during physical activity, to the authors' knowledge there is no known literature regarding hydration requirements and status of the individual pre- and post-bout specific to SUP. It could be hypothesized that if a paddler is not sufficiently hydrated (i.e., not euhydrated) prior to the start of a SUP session, they may well be adversely affected in their overall performance and possibly subject themselves to varying degrees of dehydration and heat related illnesses. Although some SUP participants carry fluid to hydrate during the session, many do not hydrate effectively during paddling despite potentially paddling for an extended period of time in a hot and humid environment.

Determining a clearer understanding of fluid loss during SUP paddling would provide initial recommendations to be developed for SUP hydration. These recommendations would allow participants to monitor their hydration status efficiently and identify when to implement more aggressive fluid consumption strategies, particularly during extended and more intense bouts of exercise especially in hot, humid environments. Due to the absence of research regarding the effects of hydration in SUP, the primary aim of this study was to identify how hydration status is affected in SUP by investigating fluid loss through measurement of nude mass during a single SUP session.

## METHODS

*Participants*

Eighteen male and twelve female SUP participants aged between 22 - 64 years were recruited from the Gold Coast, Australia for this study via communication with team coaches and contacts in the local SUP community. Paddle boarders were self-identified as either competitive or recreational, with at least one year of experience. Recreational SUP were individuals who listed SUP as their main sport or form of recreational activity and not were not actively competing. Competitive SUP were individuals who listed SUP as their main sport and competed at a local club, state, national, or international level. Individuals were excluded from the study if they reported not having adequate paddling experience, were outside the ages of 18-65 or reported being medically unwell. Ethics was granted through the Bond University Human Research Ethics Committee (RO16050) prior to commencement. Participants were informed of any associated risks and purpose of the study prior to signing an informed consent form. In addition to the consent form, personal and demographic data were collected. This data included participant's age, height, mass, years of SUP experience, hours of SUP performed each week, competency (self-rated out of 10), the environment (i.e., river, beach, open ocean), and their equipment details (i.e., board length and volume, if known). A self-reported measure of hydration of status was also obtained pre and post exercise bout. This categorical scale ranged from 1 being "not thirsty at all", 4 being "neutral", and 7 being "very' thirsty"(12). This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (13).

*Protocol*

The study protocol utilized a cross-sectional design. Each subject's hydration status was assessed by comparing the average of three measurements of nude body mass taken pre- and post- SUP session using a portable digital scale (Seca, 874, Hamburg, Germany) which was calibrated prior to testing each day and was placed on a flat, even concrete surface at the testing site. Determining fluid loss through changes in pre and post body mass have previously been deemed to be both a reliable and valid methodology to monitor hydration status, as it reflects the amount of sweat loss due to a bout of physical activity (1, 11). Prior to the SUP session commencement and data collection, all participants were required, if necessary, to empty their bladder and bowels. Each participant was also asked to then dampen their hair to mimic any moisture they may have at the end of the SUP session due to sweat or from the ocean water. Weighing was performed in a sealed off tent. If an individual was uncomfortable with removing full clothing, a loose-fitting garment was provided to ensure repeatability and was then also worn in the post measurement (dry). Prior to their post session measurement, subjects were required to dry off to the best of their ability. Subjects were also asked if any urine was voided during the session, which was then noted next to their post mass measurements. If the participant was using a water pack throughout their session for hydration, the water pack was also weighed pre and post and the difference was deducted from the post weight measurement.

Exercise Intensity: To measure the individual's exercise intensity, HR was monitored throughout the SUP session using a telemetry HR monitor watch and chest strap (Polar, FT1, Finland), with both average and peak HR, and duration being recorded.

Weather Conditions: Environmental conditions were obtained at the beginning of each SUP session at the nominated beach location using information obtained from the National Oceanic and Atmospheric Administration's buoys located offshore and interrupted through surfline.com. Details specific to wind conditions were recorded from this site. An additional weather site (Weather.com) was used to collect data on humidity and air temperature.

*Statistical Analysis*

Means and standard deviations were used to describe participant characteristics for continuous variables and proportions were used for categorical variables. Overall fluid loss was described using mean and standard deviation and a paired t-test was used to assess changes pre- and post-SUP session mass (fluid loss) as well as perception of hydration. A Spearman's Rho was used to determine the correlation between perceived hydration and percentage of body weight loss. Simple linear regression was used to determine factors associated with fluid loss. Multiple linear regression was then used to investigate multiple factors associated with total fluid loss during a SUP session. All analyses were conducted using SPSS (IBM Corp. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.). Statistical significance was set to $p < 0.05$, *a priori*.

## RESULTS

Visual inspection of the relevant histograms indicated that normality assumptions were violated, and hence parametric tests were used throughout all analyses. A total of 30 participants (18 male, 12 female) participated in this study. Eleven participants completed two SUP sessions and 1 participant completed three SUP sessions. The remaining 18 participants completed a single session. This resulted in a total of 43 trials that were analyzed (see Figure 1).

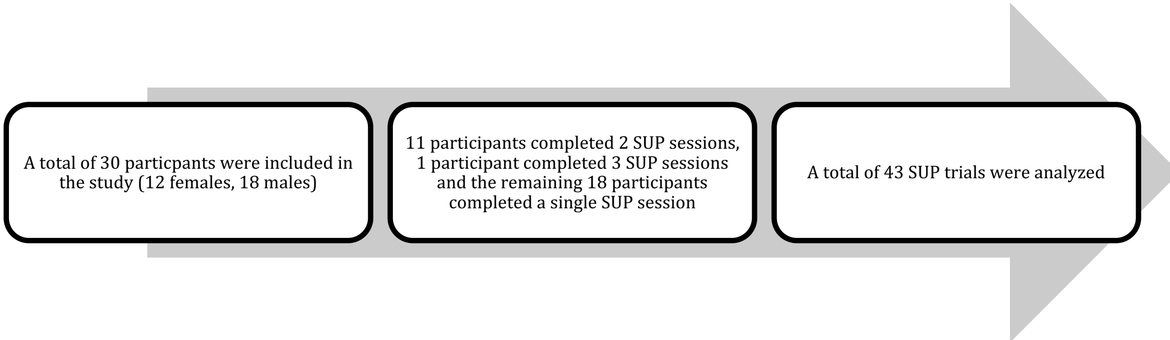


**Figure 1.** Description of participant breakdown and number of SUP trials that were included in the analysis.

On average, males were older (+ 13.9%), significantly taller ($p < 0.05$, +7.0%), and heavier (+ 18.5%) than female participants. Given the differences in height and mass, males also had a significantly ($p < 0.05$) higher BMI (+ 5.8%) and Body Surface area (BSA) (+14.4%) than female SUP participants. Males rated themselves more competent than females (+ 12.0%), despite females being more experienced in SUP (+ 16.6%). Table 1 illustrates the participants physiological characteristics.

Male SUP participants had a significantly higher ($p < 0.05$, + 15.7%) mean HR than female participants, however peak HR relative to male and female SUP was similar between genders ($p = 0.46$, 96.5% vs. 93.9%, respectively) (Table 1). With regard to exercise heart rates relative to age predicted heart rate max (220 – age), the mean SUP session HR was 77.1% for the group and 95.6% for peak exercise.

**Table 1.** Participant characteristics over 43 trials.

| Sex | *N* | Age (yrs) | Height (m) | Mass (kg) | BMI (Kg/m²) | BSA (m²) | Years of SUP | Comp-etency (1-10) | Mean Exercise HR (bpm) | Peak Exercise HR (bpm) | Duration (min) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Male | 18 | 48.11 ± 11.81 | 1.79 ± 0.08 | 80.66 ± 10.27 | 24.90 ± 1.7 | 1.99 ± 0.16 | 6.6 ± 4.3 | 7.6 ±1.6 | 140 ± 15.5* | 167.0 ± 12.9 | 68.5 ± 10.2 |
| Female | 12 | 41.44 ± 12.72 | 1.67 ± 0.05 | 65.75 ± 6.33 | 23.50 ± 2.1 | 1.75 ± 0.09 | 7.5 ± 4.3 | 7.1 ± - 2.2 | 125 ± 24.1 | 167.2 ± 23.3 | 67.0 ± 16 |
| Total | 30 | 45.63 ± 12.44 | 1.74 ± 0.09 | 75.11 ± 11.52 | 24.37 ± 1.9 | 1.89 ± 0.18 | 6.9 ± 4.3 | 7.4 ± 1.8 | 135 ± 20.3 | 167.1 ± 17.2 | 68.0 ± 13 |

Values are mean ± standard deviation (SD).

Table 2 illustrates the environmental conditions for the SUP sessions. The mean temperature was considered warm with a high humidity and low wind.

**Table 2.** Environmental variables.

| Variable | Mean | Standard Deviation (SD) |
|---|---|---|
| Air temperature (degrees C) | 22.73 | 1.65 |
| Humidity (%) | 89.81 | 5.26 |
| Wind speed (knots) | 6.88 | 4.59 |
| Duration (minutes) | 68.02 | 12.50 |

Change in Pre and Post Total Body Weight Following SUP Bout: Table 3 presents the absolute, relative and rate (per minute and per session) of fluid loss. In 17 of the 43 trials (39.5%) water was consumed during the SUP session which was adjusted for to absolute weight loss. No participants reported voiding any urine during the SUP sessions. Male SUP participants demonstrated a significantly ($p < 0.05$) greater fluid loss (total, relative to mass, relative to BMI and BSA) as compared to female SUP participants. With regard to rate of loss, males lost more fluid (45.1%) per hour and almost twice (42.9%) as much per kilogram of mass per minute (Table 3).

**Table 3.** Fluid Loss Changes.

| Outcome | Total Fluid Loss (kg) | Loss (%) | Total/BMI | Total/BSA | Kg/Min | Kg/Hr | Kg/Session mins |
|---|---|---|---|---|---|---|---|
| Male | 0.99 ± 0.5* | 1.25 ± 0.65* | 0.039 ± 0.02* | 0.50 ± 0.26* | 1.24 ± 0.65* | 0.142 ± 0.00* | 1.45 ± 0.68* |
| Female | 0.53 ± 0.3 | 0.79 ± 0.44 | 0.022 ± 0.01 | 0.30 ± 0.17 | 0.79 ± 0.44 | 0.008 ± 0.00 | 0.78 ± 0.40 |
| Total | 0.82 ± 0.4 | 1.08 ± 0.62 | 0.033 ± 0.01 | 0.43 ± 0.24 | 1.07 ± 0.61 | 0.01 ± 0.00 | 1.19 ± 0.66 |

Values are mean ± SD. Where: kg/min refers to kilograms per minute, kg/hour refers to kilograms per hour, kg/session refers to kilograms per session, % Loss refers to percentage of total body weight loss.

A two-tailed, paired samples t-test with an alpha level of 0.05 was used to compare the pre- (M=75.12, SD =1.76) and post – mass (M = 74.30, SD = 1.73) measurements of 43 trials. On average, participants post weight measurements were 0.82 kg less than their pre-weight measurements, 95% CI: 0.67 - 0.97. This difference was statistically significant ($t(42) = 10.98$, $p < 0.01$). Cohen's $d$ effect size was calculated for this difference to be 0.47, which can be described as small to medium (2). This difference is visually displayed in Figure 2 below. Males also demonstrated significantly ($p < 0.05$) greater fluid loss per kilogram per min (± 56.9%) and per hour (± 82.2%) as compared to female SUP participants. Additionally, males lost a significantly ($p < 0.05$) higher relative percentage (± 58.2%) of fluid loss over the SUP session as compared to females.

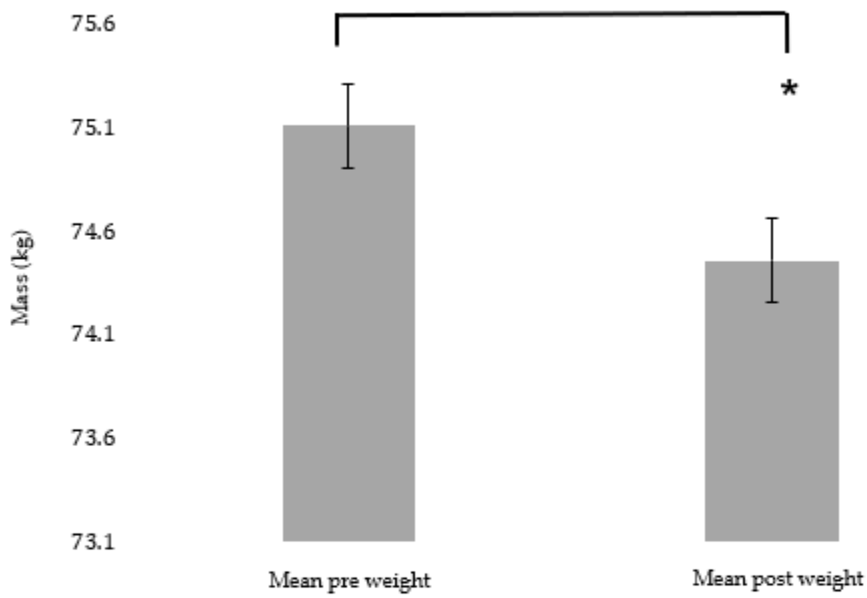


**Figure 2.** Pre and post mass changes following SUP session (values are mean ± SD). * = p < 0.05

Perceived Hydration: When investigating the SUP participants perceived hydration status, all participants who consumed water (17 trials) were removed from the data set only for the analysis of perceived hydration. A two-tailed, paired samples *t*-test with an alpha level of 0.05 was used to compare the pre- (M = 3.50, SD = 1.03) and post – perceived hydration (M = 5.54, SD = 0.65) measurements of 26 trials. On average, non-hydrated participants post- perceived hydration scores were significantly ($p < 0.01$, 95% CI: 1.59-2.49) higher (2.04 points) than their pre-event perceived hydration score. This difference was statistically significant, $t$ (26) = 9.34, $p < 0.01$. The Cohen's *d* effect size of 1.2 was calculated to reflect the magnitude of change; which can be described as a large effect (2).

A Spearman's Rho correlation test was performed to determine if there was a correlation between the amount of change in perceived hydration score and the total body weight percentage lost. Spearman's rho indicated no correlation ($p > 0.05$, $r = -0.12$) between change in perceived hydration and the percentage of total body weight lost. While the changes in perceived hydration were significant, there was no correlation with body mass change. Figure 3 illustrates that perceived hydration is not a reliable indicator for hydration status and therefore other hydration measures (i.e., color of urine, urine specific gravity) are necessary to determine hydration status or when determining a need for post-exercise rehydration strategies.

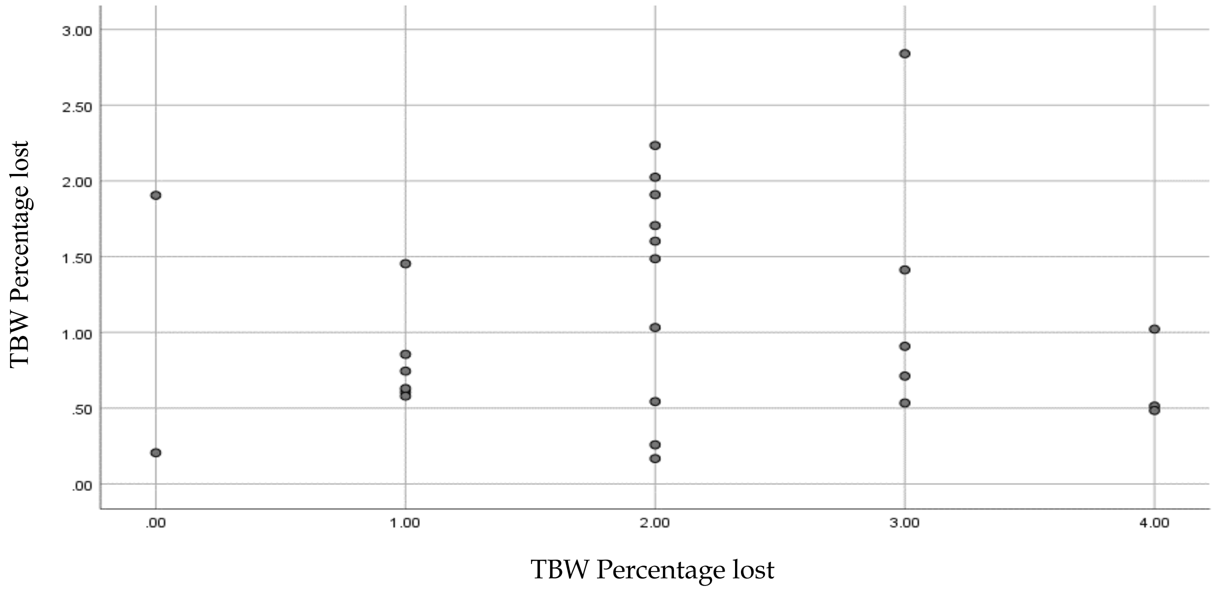


**Figure 3.** Scatter plot showing the lack of correlation between perceived hydration status and total body weight percentage lost, where TBW refers to total body weight and HS refers to hydration status.

Predictors of fluid loss: To help establish which variables were independently associated with fluid loss change simple linear regressions were performed and four variables were identified as significant (Table 4). For every 1˚ Celsius increase in ambient air temperature, there was a significant 0.17 increase in percentage of fluid loss ($p$ = 0.002). For every unit of temperature change, women had a 0.39 percentage of fluid loss less than men. For every one bpm increase in mean HR, there was a significant ($p$ < 0.001) increase in fluid loss ($p$ < 0.001). Every one-minute increase in session duration, also resulted in a significant ($p$ < 0.005) increase in fluid loss.

**Table 4.** Simple Linear Regressions.

| Predictor | Beta coefficient | 95% CI | *p*-Value |
|---|---|---|---|
| Air Temperature | 0.156 | 0.061, 0.251 | 0.002 |
| Gender | -0.393 | -0.735, -0.051 | 0.025 |
| Average HR | 0.015 | 0.007, 0.022 | <0.001 |
| Duration of Session | 0.020 | 0.008, 0.033 | 0.002 |

CI refers to confidence interval, HR refers to heart rate.

To investigate the impact of different predictors in combination and their impact on fluid loss, a standard multiple regression analysis (MRA) was performed (Table 5). When performing the MRA it was found that both duration and gender were no longer significant. However, this may be attributed to the limited sample size and limited variance of session duration. Heart rate and air temperature accounted for approximately one half (48%) of the variability in percent fluid loss among SUP participants.

**Table 5.** Multiple Linear Regression

| Predictor | Beta coefficient | 95% CI | *p*-Value |
|---|---|---|---|
| Air Temperature | 0.146 | 0.068, 0.225 | 0.001 |
| Average HR | 0.014 | 0.008, 0.021 | <0.001 |

## DISCUSSION

The aim of the current study was to investigate how hydration status, assessed via fluid loss, was affected during a SUP session. Throughout 43 trials, the average post SUP session mass (74.50 ± 11.47 kg) was significantly lower than pre-session weight (75.12 ± 11.66 kg). The overall percentage of loss across all trials was 1.09 ± 0.62 kg. Percentage of loss was examined as well as overall weight loss, as these provided a value relative to the participants' body mass that could be compared against normative data and current recommendations. Results for fluid loss in the current study were consistent with previous research completed in surf skiing and sailing (4, 5, 14, 20), when using nude mass to examine fluid loss in both elite and recreational athletes. Two studies observing surf ski paddlers resulted in mean fluid losses of 0.6 ± 0.4 kg/h from a 15-km downwind race (5), while a 35-km downwind race resulted in a loss of 0.7± 0.4 kg/h (4). Both studies reported similar results to that reported in our study (0.712 ± 0.399 kg/h). Hydration has been investigated in sailors for longer durations. For example Salter and Tan (20) investigated body mass changes in sailors whilst racing for approximately five hours (including 93 mins racing over three races). They reported the fluid loss (as determined by body mass changes pre to post) ranged from 0.57% to -2.78% in males and -0.18% to -1.5% in females. Arnaoutis and colleagues (2) also investigated dehydration in sailors competing on four consecutive days of racing, with an average race time of 130 minutes. They reported that sailors lost between 2.9% to 5.8% of mass before and following days of competition. The results from these two studies are comparable to the present study where SUP paddlers mass loss ranged from 0.79% in females SUP and 1.25% in male SUP participants (group mean: 1.08% ± 0.62).

In addition to the variance between individuals (level of training, training intensity, etc.), our findings also varied due to different weather variables for different days of training (temperature, humidity, current, and wind) and the duration of the training session, which was also supported by previous literature (16). Heart rate and air temperature accounted for 48% of the variability in fluid loss among SUP boarders in the current study, however, duration and humidity may have had more impact if there had been more variance and there were more study participants.

A study conducted by Jürimäe and colleague in rowers (7), assessed hydration status post training, as well as, 30, 60, and 120 minute marks post exercise and found that significant fluid loss continued for up to 120 minutes post training. This fluid loss ranged from 0.3 L immediately after training to 2.5 L at 120 minutes post training. This finding would suggest that monitoring body mass changes pre and immediate post session alone may not identify all fluid loss. Further monitoring after initial post bout readings in future studies may be required to identify the most accurate overall fluid loss of the participant.

From the 43 trials we investigated, 13 demonstrated a 1.5% or greater loss in their total body mass. However, most of these participants did not identify this through their perceived hydration. These results indicate that perception of hydration status was not a reliable indicator of hydration status. Osmoreceptors located in the hypothalamus sense plasma fluctuations and provide perceptions of hydration and "thirst" sensations (10). Although useful, they have been identified as variable and not always accurate; particularly in sudden drops in fluid balance, such as an intense bout of physical activity (12). In this instance, it may take longer to identify a concurrent fluid shift resulting in the individual already being in a dehydrated state before the need to hydrate is identified.

The American College of Sports Medicine guidelines define dehydration as a decrease of > 2% body mass due to water loss. The goal of adequate hydration intake is to prevent this degree of fluid weight loss (16). Internal (core temperature, sweat rates, thermoregulatory processing, etc.) and external variables (outside temperature, humidity, wind, etc.) impact the individual and dictate the need for individualized monitoring of hydration. For a rapid and complete recovery from fluid loss and or dehydration, it is recommended that an individual should consume ~1.5 L of fluid for each kilogram of body mass lost (16, 19). The volume required is higher than the weight lost to compensate for urine production and excretion that will naturally increase following an increased uptake of fluid over a short time period (16, 19). It is preferential, if the participant has a longer recovery period (< 12 hours) that they rehydrate over a longer time span to maximize fluid retention and rehydration (9, 16).

There are several limitations of the study that need to be considered when interpreting and generalizing results outside of the study. Medications and supplements of the participant were not investigated and may have resulted in a greater or lesser fluid loss of the individual (15). Additionally, there are individual factors such as genetic predisposition, acclimatization to heat and metabolic efficiency that will impact sweat rate. Pre-SUP session fluid and food intake were also not monitored and no restrictions in hydration or caloric intake were set pre or post event. Hydration was only investigated through changes in body mass. If urine specific gravity (USG) or blood samples had been taken, hydration status of the participant could have been objectively defined pre event rather than exclusively as a subjective measure of perceived hydration (21). Previous studies investigated hydration over a prolonged duration, whereas the sessions monitored in this study were an average of 60 - 80 minutes. The data set was also small, and data was only collected at one time of year (summer), which may have limited findings of other variables that are known to impact fluid loss.

Future research should assess the participants' hydration status pre session or pre-intervention with USG as this would quantify the participants hydration status prior to participating. Further research specifically investigating hydration status in unsubmerged water sports pre and post exercise session, with monitoring for up to 90 minutes after the exercise session is warranted to identify risk of negative physiological impacts on performance. In addition, a larger data set and monitoring prolonged session durations of SUP would allow for more variance and further analysis of the above variables.

Based upon the findings of this study and those studies using similar characteristics it was identified that SUP paddlers who participated in warmer air temperatures, higher humidity, and exercised at a higher intensity for a prolonged period of time may be at risk of fluid loss and dehydration at a level that would compromise their exercise performance and pose a health risk. Participants should monitor their body mass pre- and post-session for a more accurate representation of fluid loss on a given day of training, particularly during more intense bouts to determine rehydration requirements. If accelerated rehydration is required, especially if the recovery period is less than twelve hours, then it is recommended that ~1.5 liters of replacement fluid should be consumed for every kilogram of body fluid lost. The optimal goal for both recreational and competitive SUPs should be to maintain a euhydrated state with normal electrolyte balances before commencing activity through regular diet, including planned rehydration following the SUP session.

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